

Effects of the Effect of Ultra High Frequency Mobile Phone Radiation on Human HealthMosa Moradi¹, Nasrollah Naghdi², Hamidreza Hemmati³, Majid Asadi-Samani⁴, Mahmoud Bahmani⁵

¹ M.Sc. of Medical Radiation, Department of Radiation Medicine, Faculty of Nuclear Engineering, Shahid Beheshti University, Tehran, Iran

² Head of Food and Drug Administration, Clinical Microbiology Research Center, Ilam University of Medical Sciences, Ilam, Iran

³ Ph.D. of Medical Radiation, Department of Radiation Medicine, Faculty of Nuclear Engineering, Shahid Beheshti University, Tehran, Iran

⁴ Ph.D. Student of Medical Immunology, Student Research Committee, Shahrekord University of Medical Sciences, Shahrekord, Iran

⁵ Ph.D. Student of Medical Microbiology, Lorestan University of Medical Sciences, Khorramabad, Iran

Type of article: Original**Abstract**

Introduction: Public and occupational exposure to electromagnetic fields due to the growing trend of electronic devices may cause adverse effects on human health. This paper describes the risk of mutation and sexual trauma and infertility in masculine sexual cell by mobile phone radiations.

Methods: In this study, we measured the emitted dose from a radiofrequency device, such as switching high voltage at different frequencies using a scintillation detector. The switching high voltage power supply (HVPS) was built for the Single Photon Emission Computed Tomography (SPECT) system. For radiation dosimetry, we used an ALNOR scintillator that can measure gamma radiation. The simulation was performed by MATLAB software, and data from the International Commission on Non-Ionizing Radiation Protection (ICNIRP) were used to verify the simulation.

Results: We investigated the risks that result from the waves, according to a report by International Commission on Non Ionizing Radiation Protection (ICNIRP), to every organ of the body is defined by the beam and electromagnetic radiation from this electronic device on people. The results showed that the maximum personal dose over a 15-min period working at the mentioned HVPS did not exceed 0.31 $\mu\text{SV/h}$ (with an aluminum shield). So, according to other sources of radiation, continuous working time of the system should not be more than 10 hours. Finally, a characteristic curve for secure working with modules at different frequencies was reported. The RF input signal to the body for maximum penetration depth (δ) and electromagnetic energy absorption rate (SAR) of biological tissue were obtained for each tissue.

Conclusion: The results of this study and International Commission of Non Ionization Radiation Protection (ICNIRP) reports showed the people who spend more than 50 minutes a day using a cell phone could have early dementia or other thermal damage due to the burning of glucose in the brain.

Keywords: Radiofrequency, Mobile Phone, Radiobiological Effects, Mutation, ICNIRP

1. Introduction

Many people are not aware of the harmful effects of radiofrequency waves (RF) and their role in cancer and other serious risks. Scientific evidence suggests that cancer is not only linked to mobile phone radiation and that other factors also may be involved in its development. Most mobile operators use from radiofrequency waves in the range up 300 MHz to 3 GHz that can be harmful for human health (1). Many scientific studies have been done on the radiobiological effects of RF waves, and most of them have reported the rare relationship between RF exposure and

Corresponding author:

Dr. Nasrollah Naghdi, Ilam University of Medical Sciences, Ilam, Iran.

Tel: +98.2232523, Fax: +98.2232521, Email: dr.naghdi93@gmail.com

Received: January 12, 2016, Accepted: April 11, 2016, Published: May 2016

iThenticate screening: April 11, 2016, English editing: April 20, 2016, Quality control: April 26, 2016

© 2016 The Authors. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

risks posed by mobile phones on the body in the last 15 years (2). However, they could lead to increased body temperature, especially in the head and neck, who have a low threshold dose and increases the probability of injury if there is long-term exposure to these waves. Mobile phones emit RF waves even when they are in standby mode. When using mobile phones, various factors should be considered, such as the duration, location, and method of use, in order to reduce the possible effects of exposure to radiation in the RF. Because of the risk of mutation and sexual trauma and to prevent infertility due to the effect on male sexual cells, the mobile phone should be away from the waist. In this study, we measured the emitted dose from a radiofrequency device at different frequencies using a scintillation detector. The results of this study and International Commission of Non Ionization Radiation Protection (ICNIRP) reports show that people who use cell phones more than 50 minutes a day face early dementia or other thermal damage due to the burning of glucose in the brain (3). Currently, the ranges of subjects related to occupational and public exposure of electromagnetic fields have been increased. Due to the possibility of adverse effects on human health, performance study of these devices has significant importance (4). There are two types of electromagnetic fields based on the frequency range, i.e., extremely low frequency (ELF) and very low frequency (VLF) fields. ELF and VLF fields' frequency ranges are between 3 and 300 Hz and 3 and 300 kHz, respectively. Due to the nature of static electricity, electric and magnetic fields at these frequencies operate separately from each other and will be measured in the different circumstances (5). Electric and magnetic fields can be produced by carrying of electric current at any wiring or equipment, such as overhead or underground power lines, home wiring, medical equipment, and electronic devices (6). The most important factors that influence human exposure are power density of the frequency generator source, distance from the source, type and thickness of the exposed beams, and frequency (penetrated depth) of the RF input signal to the body (7). Figure 1 shows the frequency ranges of electromagnetic fields.

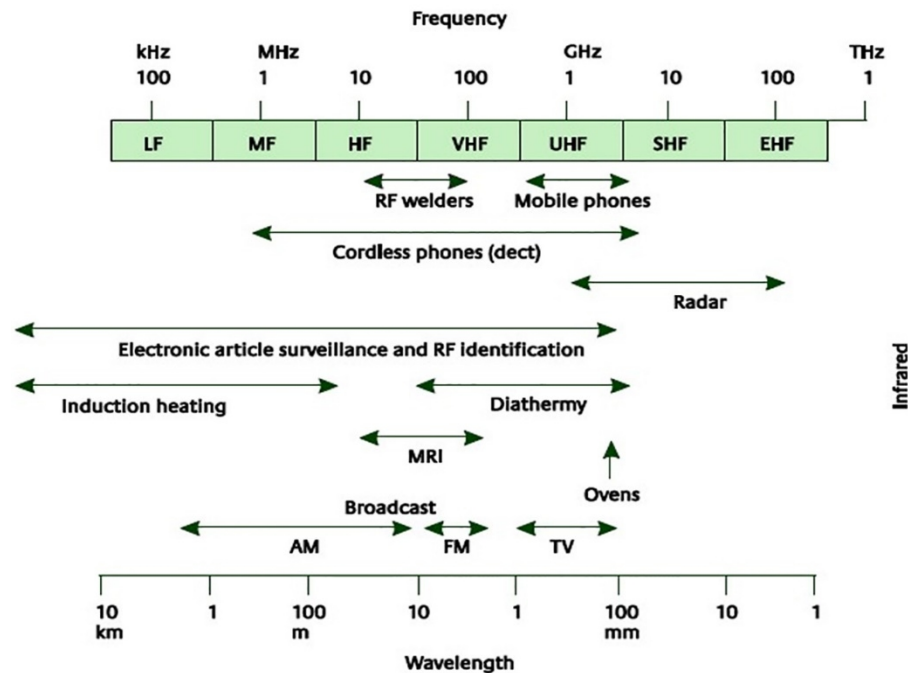


Figure 1. Electromagnetic fields according to the frequency ranges (4).

2. Material and Methods

2.1. The Switch Mode High Voltage Module (SMHVM)

The High Voltage Power Supply (HVPS) that was used in this study was made based on the push-pull topology (4-8). It was designed and built for the Single Photon Emission Computed Tomography (SPECT) system, and its performance was evaluated through simulation as well as experiment. The nominal frequency of SHVPS is about 31 kHz that is achieved in half of the duty cycle. Some module specifications, such as the maximum intensity of the magnetic field (B_{max}), output voltage (V_o), output current (I_o), maximum switching frequency (F_{max}), reference voltage (V_r), and bias voltage are $B_{max} = 200$ mT, $V_o = 2000$ V, $I_o = 20$ mA, $F_{max} = 60$ kHz, $V_r = 5.5$ V, and $V_c = 12$ V, respectively. Figure 2 shows the prototype model of the constructed module. In switched mode power supplies, switching frequency interference results in a sudden flow of electric and magnetic fields. Thus, to reduce the effects of interference, Electromagnetic Interference (EMI) filters and RF shielding are used.



Figure 2. The prototype of constructed high voltage power supply module.

2.2. RF Dosimetry

The body exposure that is caused by RF waves of electric and magnetic fields, which varies with the intensity of the output signal was determined. Usually energy measurement of transmitted RF signals that enters the body is not exactly possible. However, it can be estimated and predicted. For quantification of the exposure effects on the human body, the term used is dosimetry (dosimetric quantities). Other quantities related to the exposure of tissue include the electric field strength, the induced current in the body, and the rate of energy absorbed by the external field. The dosimetry role is to evaluate the amount of the induced electric fields in the body. Also, the dosimetry term often is used to connect the body and the biological effects resulting from energy absorption of electromagnetic waves. To measure the absorbed energy in the body by RF wave that was emitted from the HV module, an ALNOR dosimeter was used in this study. Usually, the exposure limit is expressed by specific absorption rate (SAR), which is a measurable metric. SAR is the time rate at which electromagnetic energy is absorbed in a biological tissue and can be expressed as (9, 10):

$$(1) \quad SAR = \frac{\sigma E_{rms}^2}{\rho},$$

where σ is specific conductivity $S m^{-1}$, E_{rms} is the effective amount of field in tissue, and ρ is the density of the radiation-exposed tissue, which, for the head is $1.027 (gr cm^{-3})$. Because the head is the most important member of the body, it is necessary to express the above parameters for this body part. For head limb σ at room temperature is $1.79 (S m^{-1})$, E_{rms} for this module at 1.5 m distance from the dosimeter (on the head) is $1500 (V m^{-1})$ and density of it is $1.027 (gr cm^{-3})$.

2.3. RF penetration depth measurements

The penetration depth of the RF wave enters into biological tissues and the frequency of the emitted wave are inversely related. The electric field due to the RF input signal to the body will decrease after a distance from its original amount (Griffiths, 1989), known as the skin depth (Figure 3). The skin depth of each tissue type organ depends on the electrical permittivity and conductivity.

$$(2) \quad \delta = \frac{1}{\omega} \left\{ \frac{\mu \varepsilon}{2} \left[\left(1 + \left(\frac{\sigma}{\omega \varepsilon} \right)^2 \right)^{\frac{1}{2}} - 1 \right] \right\}^{\frac{1}{2}},$$

where ω is the angular frequency, μ , σ , and ε are magnetic permeability of materials, conductivity (S m^{-1}), and permeability, respectively. Usually, μ in tissues has essentially the same value as in free space, $4\pi \times 10^{-7}$ (H m^{-1}). The relationship between skin depth of RF waves and frequency is shown in Figure 4.

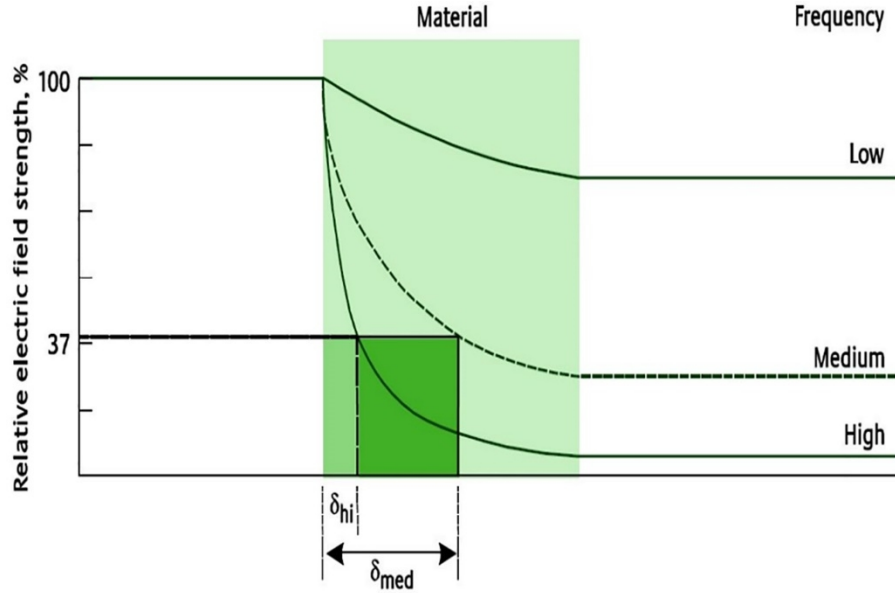


Figure 3. Relation between RF wave depth penetration and emitted frequency from generator (4).

3. Results

In Table 1, the maximum allowable working with high frequency sources, according US Federal Communication Commission (FCC), is shown. According to the first row of Table 1, at the frequencies of 15 to 60 kHz, the maximum work time for an operator should not be more than 6 min. To determine the intensity of magnetic field exposure limit values are effective values (rms) is given. In this study, the value of B at 25 kHz switching frequency is 2.4 mT. Figure 4 demonstrated the dose rate received to dosimeter, at a distance of 1.5 meters from the module. The row data for calculation Cumulative dose and relationship between the penetration depths of RF wave entrances to body with the frequency of emitted wave at different distances from module can be collected. As is clear from the results, the penetration depth of the wave RF and the frequency of the emitted wave is inversely: ($\delta \propto f_s^{-1}$).

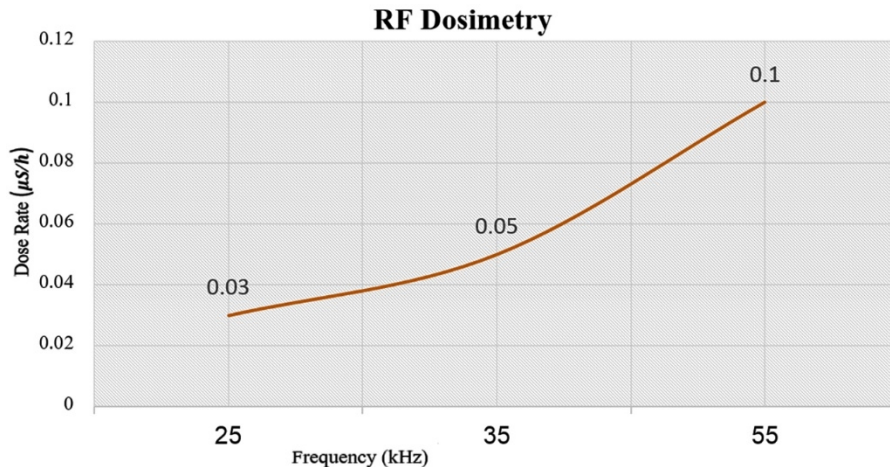


Figure 4. The dose rate at a distance of 1.5 m from the module (measured by ALNOR dosimeter)

Table1. FCC Limits for Maximum Permissible Exposure (MPE).

Frequency (MHz)	Electric Field Strength; RMS (V m ⁻¹)	Magnetic Field Strength; RMS (A m ⁻¹)	Power Density(w m ⁻²)	Averaging Time (min)
0.003-1	600	4.9	-	6
1-10	600*f ¹	4.9*f ¹	-	6
10-30	60	4.9*f ¹	-	6
30-300	60	0.163	-	6
300-1500	3.54*f ^{0.5}	0.0094*f ^{0.5}	f *30 ⁻¹	6
1500-15000	137	0.364	50	6
15000-150000	137	0.364	50	616000*f ^{1.2}
150000-300000	0.354*f ^{0.5}	9.4*10 ⁻⁴ *f ^{0.5}	3.33*10 ⁻⁴	616000*f ^{1.2}

4. Discussion

Numerous epidemiological studies, the association between public and occupational exposure, particularly exposure to ELF fields and the risk of Cancer, including leukemia, brain tumors and breast cancer has shown (8). An internal EM field is induced in the tissue when a biological tissue is exposed to RF waves (11). According to American Conference of Governmental Industrial Hygienists (ACGIH) and ICNIRP reports (7), the normal occupational exposure limit, for the whole body, not to exceed 60 mT or 600 G. Occupational exposure limit values of the magnetic flux density of the magnetic field with a frequency range 30 kHz and less than it, refers to a value that if employees are frequently faced with it, does not have any negative effect on their health. To determine the intensity of magnetic field exposure limit values are effective values (rms) is given. Occupational exposures in the range of extremely low frequency (ELF) 1 Hz to 300 Hz, the amount shall not exceed the ceiling provided in the link below:

$$B = \frac{60}{f}(3)$$

In the above equation, the level of exposure by tesla (T) and f is the frequency in Hz. Occupational exposures in the frequency range of 300Hz to 30 kHz (including audio frequency band [VF] from 300 Hz to 3 kHz and very low frequency band [VLF] is the 3 kHz to 30 kHz) shall not exceed the ceiling 0.2 mT. Exposure limit values for frequency of 300Hz to 30 kHz, including the body and is also part of the body. At frequency of 35 kHz (nominal module frequency) maximum value of δ factor is equal to 19.9 μ m in the middle of the skull bone (1 to 7 mm) is much less, but the RF energy can penetrate into the brain in the area of the bone in place leaves. Hypotension, dizziness, insomnia, headaches, loss of memory, etc. (12). There is also the direct effects of long-term cancer risk. The as Low as Reasonably Achievable (ALARA) rules are necessary.

5. Conclusions

NCRP-86 reporting threshold of biological effects caused by occupational exposure to RF radiation absorption to 0.4 (W Kg⁻¹) determined according to the amount of 39.21 (W Kg⁻¹) of this module is to measure the duration of the ongoing work in the once the device should not exceed 15 min. Also, in switching power supplies, there are long lines of communication between circuits components can reduce the effectiveness of high-frequency filters that this will lead to an increase in exposure. In general, considering that mental and psychological effects of these fields has been reported in small quantities, In order to control the possible harmful effects RF fields as possible from exposure. In this field, through the reduction of working time with a beam and the distance of the field with equipment distance and the training of personnel exposed to radiation, is prevented.

Acknowledgments:

This work is a part of a large project aimed at developing an accurate, low ripple and safe high voltage power supply for using in the medical equipment. It is supported in part by Shahid Beheshti University and Research Center for Molecular and Cellular Imaging, Tehran University of Medical Sciences, Tehran, Iran. Also, it received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest:

There is no conflict of interest to be declared.

Authors' contributions:

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

References:

- 1) Drossos A, Santomaa V, Kuster N. The dependence of electromagnetic energy absorption upon human head tissue composition in the frequency range of 300-3000 MHz. (IEEE) Trans Microwave Theory Tech. 2000; 48(11): 1988-95. doi: 10.1109/22.884187.
- 2) Ahlbom A, Green A, Kheifets L, Savitz D, Swerdlow A. Epidemiology of health effects of radiofrequency exposure. Environ Health Perspec. 2004; 112(17): 1741-54. doi: 10.1289/ehp.7306. PMID: 15579422.
- 3) London SJ, Thomas DC, Bowman JD, Sobel E, Cheng TC, Peters JM. Exposure to residential electric and magnetic fields and risk of childhood leukemia. Am J Epidemiol. 1991; 134(9): 923-37. PMID: 1843457.
- 4) D'Antone I, Lolli M, Zanotti M. High voltage generator for the power supply of photomultipliers in the time of flight system of Alpha Magnetic Spectrometer-2 experiment. Nucl Instr Meth Phys Res. 2002; 480(23): 555-64. doi: 10.1016/S0168-9002(01)01222-0.
- 5) Habash RW. Electromagnetic fields and radiation: Human bioeffects and safety, CRC Press, 2001.
- 6) Knave B. Electromagnetic fields and health outcomes. Ann Acad Med Singapore. 2001; 30(5): 489-93. PMID: 11603131.
- 7) Advisory group on non-ionising radiation. Health effects from radiofrequency electromagnetic field. 2012: 978-0-85951-714-0.
- 8) Brown M. Power Supply Cookbook. 2nd ed. Boston Oxford Johannesburg Melbourne, New Delhi Publication, 2001. ISBN-13: 978-0750694421.
- 9) Stevens N, Martens L. Comparison of Averaging Procedure for SAR Distribution at 900 and 1800 MHz. (IEEE) Trans Microwave Theory Tech. 2000; 48(11): 2180-4. doi: 10.1109/22.884212.
- 10) Jha BK. Effects of electromagnetic fields on human beings and electronic devices. Himalayan Physics. 2012; 3(3): 38-9. <http://www.nepjol.info/index.php/HP/article/view/7274>.
- 11) Bernardi P, Pisa S, Puizzi E. Specific absorption rate and temperature increases in the head of a cellular-phone user. (IEEE) Trans Microwave Theory Tech. 2000; 48(7): 1118-26. doi: 10.1109/22.848494.
- 12) Becker RO, Marino AA. Electromagnetism and Life, State University of New York Press, 1982.